

Reply to Barbraud *et al.*: King penguin population threatened by Southern Ocean warming

Barbraud *et al.* (1) question the significance of our study (2), arguing that only population models based on statistical modeling of longer time series can provide robust conclusions. We have used these techniques elsewhere but here use a complementary approach: the investigation of the functional processes/ecological mechanisms linking climate fluctuations to life history traits. We did not work on population growth rate (note that king penguin main colonies on Possession Island are no longer increasing) and thus did not test density dependence in our population. Nor were El Niño events used as a surrogate for long-term climate trends. Instead, we used numerous environmental factors at different temporal and spatial scales as proxies for predicted aspects of global warming (3). In a mechanistic aspect, our time series of 9 years (i.e., almost two generations) are sufficiently long to answer our question as to what happens with fundamental fitness components when environmental conditions are changing (i.e., short, proximate relationships). Our analyses and conclusions are therefore robust. The key point missed by Barbraud *et al.* (1) is the dependence of king penguin, a sub-Antarctic species, on Antarctic winter sea ice (4). Regardless of current population trends or that these animals are long-lived, it is then legitimate to consider an extinction risk as observed in other ice-dependent populations. For instance, Western Antarctic Peninsula populations have dropped dramatically, especially since the 1990s, by 82%, 70%, and 90% since the mid-1970s for Weddell seals, Adélie penguins, and emperor penguins, respectively (5, 6). Yet any “understanding” of the effects of climate changes will remain naïve without integrating population dynamical, behavioral, and physiological insights to explain them (7).

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